Effect of Speech Recognition Testing on Self-Reported State Anxiety

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by

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Abstract

The effect of difficult listening situations on anxiety levels has not been tested on middle-aged adult and older adult populations. In order to determine if a relationship exists between difficult listening situations and anxiety levels, self-reported levels of state anxiety were measured pre- and post-speech recognition testing in young adults, middle-aged adults, and older adults. Four measures of speech recognition where used: the Revised-Speech Perception in Noise test (R-SPIN), the Quick Speech-in-Noise test (QSIN), the Words-in-Noise test (WIN), and the VA Dichotic Digits test. Thirty young adults with normal hearing, 19 middle-aged adults with minimal sensory-neural hearing loss, and 17 older adults with no more than a moderately-severe sensory-neural hearing loss participated. Results revealed no significant differences in state anxiety levels as a function of age. Within each age group, significant increases in anxiety levels were found. Young adults had significant increases in anxiety levels post-Dichotic Digits. Middle-aged adults had significant increases in anxiety levels post-RSPIN, post-QSIN, post-WIN, and post-Dichotic Digits. Older adults had significant increases in anxiety levels post-QSIN and post-Dichotic Digits. Changes in state anxiety levels were variable within each age group and did not follow any trends, except for an overall increase in anxiety levels post-Dichotic Digits test. Speech recognition testing performance in young adults and middle-aged adults was comparable on all four measures of speech recognition. Older adult speech recognition testing performance was significantly poorer than both young and middle-aged adults on all four measures of speech recognition. Results of the present study suggest that changes in state anxiety are variable by individual, but do not necessarily affect performance on speech recognition testing. However, consistent increases in anxiety levels for Dichotic Digits suggests that additional counseling and encouragement could be beneficial to patient comfort.

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Chapter 1

Introduction and Literature Review

Introduction

Communication is a vital part of human life. Communication allows for people to share ideas and is a way to develop interpersonal relationships. Hearing loss, however, negatively impacts communication, often to the point of communication breakdown. Hearing loss is one of the most common disabilities in the United States, and its prevalence increases with age (Mehra et al., 2009; Agrawal et al., 2008). Presbycusis, or hearing loss due to aging, is the third most prevalent chronic condition in older Americans, impacting approximately one-third of all people greater than 65 years of age (Raynor et al., 2009). A first sign of hearing loss occurs when a person complains of difficulty understanding speech, especially in noisy environments (Kramer et al., 1998). Thus, speech understanding is evaluated clinically in order to address this complaint and is referred to as speech recognition testing.

Commonly, speech recognition testing involves presenting monosyllabic words in quiet. The patient then verbally repeats the words and performance is measured in percent correct. Speech recognition testing is often measured at multiple levels in order to find the level for optimal recognition performance. Speech recognition testing does not, however, address the patient's complaints of difficulty understanding speech in noisy environments. In order to address this complaint, the difficulty of speech recognition task must be increased in order to mimic the environments that are most difficult for the patient. An increase in the difficulty of the speech recognition task can be achieved by adding a noise competitor. Background noise, such as speech spectrum noise or multitalker babble, competing speech signals to the ears, such as in dichotic listening, are ways that can increase test difficulty. The intensity level in which the noise competitor is presented varies with respect to the speech signal, called the signal-to-noise ratio (SNR), in order to change the difficulty of the task. More difficult tasks have a lower SNR, and vice versa.

By manipulating the listening environment, the speech recognition testing offers a very sensitive measure of a patient's perceptual abilities in difficult listening situations. However, because speech recognition tests present patients with unique or difficult listening environments, speech recognition tests are also difficult for the patients. Difficulty in testing induces many different reactions in patients. One reaction a patient may have to a difficult testing situation is an increase in anxiety.

Anxiety has a long and complex history with academic testing. Beginning in the 1950s, Mandler and Sarason (1952) first suggested that high anxiety levels in testing negatively affect performance. A study by Hembree (1988) illustrated many different causes of anxiety related to testing. Test anxiety, as revealed by Hembree, is inversely related to self-esteem and performance in most cases. Test anxiety is directly related to other forms of anxiety, including anxieties surrounding ability, gender, and age. The influences of other forms of anxiety on test anxiety vary by individual (Hembree, 1988).

Emotions influence the amount test anxiety an individual experiences and impact the effects of test anxiety on learning and achievement. The relationship between emotionality and test performance is complex: negative emotions have the ability to produce both facilitating and debilitating effects on performance (Perkrun, 1992). Spielberger (1995) stated that as task difficulty increases, the likelihood that anxiety produces debilitating effects on test performance increases. Conversely, as task difficulty decreases, anxiety is more likely to yield facilitating effects on test performance (Spielberger, 1995).

Proficiency of the individual at the task being tested also changes the impact test anxiety has on performance. The effects of test anxiety are augmented if an individual has low proficiency on the task being tested (Zeidner, 1998). Proficiency of the individual can be improved by increased experience with the task (Ball, 1995). In some situations, task difficulty can be great enough that the resulting anxiety is always debilitating, regardless of an individual's proficiency.

Speech recognition testing can be a difficult task, especially in a degraded condition, and therefore may induce anxiety in patients. Because the results of speech recognition testing are used to make decisions affecting treatment and anxiety can affect test performance, it is imperative to discover the affect that increasing states of anxiety have on performance on speech recognition tests. Research shows that self-reported anxiety levels increase as a result of dichotic listening, or simultaneous competing stimuli, tasks in young adults with normal hearing (Roup & Chiasson, 2010). However, young adults are not a clinically relevant population. Therefore, the present study tested middle-aged adults with minimal hearing loss and older adults with hearing loss, as both are clinically significant populations.

The primary purpose of the present study was to examine if anxiety levels change as a result of speech recognition testing. To do this, self-reported state anxiety levels as a function of speech recognition test performance were measured in three groups of listeners: young adults with normal hearing, middle-aged adults with minimal hearing loss and older adults with varying degrees of hearing loss. The results were then compared across and within age groups.

HYPOTHESIS:

I. Subjects will report increased states of anxiety as a function of the increasing degradation of the speech stimulus in speech recognition tests.

II. Middle-aged adults with minimal hearing loss will exhibit greater levels of anxiety than older adults due to the fact that older adults expect listening difficulties whereas middle-aged adults do not.

In order to test the hypotheses, the following **SPECIFIC AIMS** are proposed:

I. To compare the changes in self-reported state anxiety as a result of speech recognition testing in young adults with normal hearing, middle-aged adults with minimal hearing loss, and older adults with varying degrees of hearing loss to see if a relationship between change in anxiety level as a result of speech recognition tests and age is present.

II. To compare the results of self-reported state anxiety levels and recognition performance within each age group to see if a relationship between anxiety and recognition performance on individual tests is present.

Speech Recognition Testing

The audiologic examination is used to test the function and integrity of the auditory system. This includes pure tone threshold testing, which is used to determine a patient's pure tone thresholds. Another part of the audiologic examination is speech recognition testing. Speech recognition testing is used to determine how well a patient can perceive speech. Most often, speech recognition tests use monosyllabic words in quiet. The patient verbally repeats these words, and performance is measured by percent correct. This process is repeated at multiple loudness levels in order to find the level at which recognition performance is optimal. This type of speech recognition testing, however, does not address speech understanding in noisy situations, which is often a complaint.

In order to test noisy situations, noise competitors are added to speech recognition tests. Adding noise competitors in speech recognition testing creates a more life-like test situation, thus addressing patients complains to speech understanding in noise. Noise competitors include background noise and competing speech signals. The patient must then attend to the target speech signal and repeat the speech signal to the examiner. The intensity level in which the noise competitor is presented varies with respect to the speech signal, called the SNR, in order to change the difficulty of the task. More difficult tasks have a lower or negative SNR, and vice versa.

The results of speech recognition testing are used to identify hearing performance deficits that might not be predicted by pure-tone threshold losses. By using speech recognition testing with the presence of noise competitors, audiologists can better understand a patient's day-to-day hearing abilities. Therefore, speech recognition testing with noise competitors is an important part in the development of a treatment plan that best suits a patient's needs.

Effect of Hearing loss on Speech-in-Noise Performance

Speech-in-noise tasks are a type of speech recognition test that are designed to put strain on the auditory system. Listeners must attend to a speech signal while ignoring any unwanted noise competitors. Speech signals used in speech-in-noise tasks include syllables, words, or phrases. Noise competitors include white noise, broadband noise, filtered noise, single talker babble, and multi-talker babble.

Hearing loss often negatively effects speech-in-noise performance; however, the degree of performance deficit is diverse and cannot be predicted by degree of hearing loss (Killion, et al., 2004). Killion et al. (2004) showed such diverse performance of hearing-impaired subjects in developing the Quick Speech-in-Noise (QSIN) test that normative data for hearing impaired individuals could not be extracted. Variability in performance on speech-in-noise tasks in hearing-impaired individuals occurs because SNR loss, the SNR needed to achieve 50% correct, cannot be accurately predicted from hearing thresholds presented on an audiogram (Killion and Niquette, 2000). Despite this variability, performance on speech-in-noise is worse in hearing impaired individuals than in normal hearing individuals (Dubno, Dirks, & Morgan, 1984; Souza & Turner, 1994).

The type of noise competitor can also adversely affect performance. A study by Souza and Turner (1994) analyzed the effects of noise competitor properties on performance of hearing impaired listeners on speech-in-noise tasks. Souza and Turner tested three groups of listeners:

young adults with normal hearing, young adults with a sensorineural loss, and older adults with a sensorineural hearing loss. Young and older adults with sensorineural losses were closely matched to control for any degree of loss effects. Three types of noise competitors were used: speech-spectrum noise, speech-spectrum noise temporally modulated by the envelope of multi-talker babble, and multi-talker babble. In each of the three types of noise-competitors, hearing impaired individuals performance was consistently lower than normal hearing individuals. However, results revealed that there was not a relationship between group and condition, showing that normal hearing individuals and individuals with hearing loss were similarly affected by the type of noise competitor. Although the effect of the masker condition was not statistically significant, the results revealed a trend towards poorer performance as the masker condition more closely resembled speech babble.

Effects of Aging on Speech-in-Noise Performance

Numerous studies have shown that older adults typically are less proficient at speech-in-noise tasks than their young adult counterparts (Gordon-Salant, 1986; Tun, Wingfield, & O'Kane, 2002; Souza & Turner, 1994; Dubno, Dirks, & Morgan, 1984; Yilmaz et al., 2007). Dubno et al. (1984) showed that older adults were less proficient at speech-in-noise tasks than young adults even when degree of hearing loss is the same. Dubno et al. evaluated speech-in-noise for four groups: young adults with normal hearing, young adults with a mild sensorineural hearing loss, older adults with normal hearing, and older adults with a mild sensorineural loss. Young adults were defined as younger than 44 years old; older adults were defined as older than 65 years old. The normal hearing young adults and normal hearing older adults had equivalent speech recognition performance in quiet. Similarly, both the young and older hearing impaired adults had equivalent speech recognition performance in quiet. Despite equivalent speech recognition performance in quiet, older adults performed significantly worse in speech recognition performance in noise as compared to the younger adults for both of the normal-hearing and hearing-impaired groups. Within age groups, the hearing impaired listeners performed significantly worse on speech recognition tasks in both quiet and noise than their normal hearing peers. The results of the Dubno et al. study demonstrate the difficulty older adults have with speech-in-noise tasks, even when controlling for degree of hearing loss. Thus, older adults have decreased proficiency in speech-in-noise tasks.

The type of noise competitor can also negatively affect speech-in-noise performance in older adults. Tun, Wingfield, and O'Kane (2002) investigated the effect of the type of noise competitor on speech-in-noise performance in both young and older adults with normal hearing. The noise competitors used were meaningful speech, non-meaningful speech composed of randomly ordered word strings, and speech in an unfamiliar language. Results revealed that older adults, but not young adults, were impaired more by meaningful noise competitors than by non-meaningful noise competitors and speech competitors in an unfamiliar language. Furthermore, young adults were more likely to recognized meaningful noise competitors than older adults when asked to choose if the meaningful noise competitor was presented concurrently with the speech signal. Thus, Tun et al. demonstrated that older adults have more difficulty than young adults processing speech-in-noise in both meaningful and non-meaningful noise competitors. Additionally, older adults will have difficulty analyzing both the meaningful noise competitor and the desired speech signal if a meaningful noise competitor is used.

Many listening environments in the real-world contain background noise that consist of meaningful speech signals. Such situations include noise from the radio, television, and other people. Thus, speech-in-noise tasks that use meaningful speech signals are clinical re-creations of realistic difficult listening situations. Because both the Tun et al. study and the Souza and Turner study showed that meaningful speech was the noise competitor that caused the worst speech-in-noise task performance in older adults and meaningful speech most closely resembles real-world situations, processing speech in real-world situation is significantly more difficult for older adults than for young adults.

Furthermore, Nittrouer and Boothroyd (1990) showed that older adults use contextual information to a greater extent that both children and young adults when attempting to correctly identify phonemes in works and words in sentences. Thus, older adults have more difficulty in situations in which the desired speech signal is not often used in daily speech or does not have sufficient contextual information. By decreasing the commonality of a stimulus word and the contextual information that is presented with the target word, the stimulus word is more difficult to predict.

Older adults also show tendencies to respond to spoken stimuli as though they understood the stimuli correctly, even if this is not the case. Gordon-Salant (1986) uses signal detection to explain this phenomenon. In this study, subjects were asked to identify a stimulus and then judge the accuracy of their responses. Older adult subjects were slower to identify the stimulus, but reported a higher confidence than their young adult counterparts in the accuracy of their responses. Gordan-Salant attributes this to the familiarity of older listeners with guessing at responses in daily life. This familiarity with guessing could cause older adults to become overconfident in their abilities. However, Rogers, Jacoby, and Sommers (2012) showed that older adults were more prone to "false hearing" or the mistaken high confidence in the accuracy of perception when a spoken word has been misperceived. Rogers et al. attributed these findings to older adults' bias to respond consistently with context, rather than familiarity with guessing or a greater skill level in using context. Thus, although older adults consistently perform worse in difficult listening situations, older adults are also more reluctant to admit the presence of listening difficulty.

The anecdotal claim that auditory perception declines with age is supported by the research literature. There are many theories on the cause of these auditory declines. Barrenas and Wikstrom (2000) propose that high frequency sensory neural hearing loss is the main contributing factor affecting an older listener's ability to perceive and interpret speech signals. The idea that hearing loss in older listeners causes auditory perception declines mirrors data on hearing loss prevalence in the older adult population: over 80% of those over 85 years of age experience age-related hearing loss (Lin et al., 2011). Kinsbourne (1970) suggests that declines in memory and cognition are responsible for the declines in auditory perception. Additionally, Bellis and Wilber (2001) theorize that declines of signal transmission across the corpus collosum are responsible to the auditory declines in older adults. Rogers et al. reason that these declines could also be associated with a decline in frontal-lobe functioning. While none of these theories have been unanimously proven, it is evident that auditory processing ability declines with age.

Declines in auditory perception, however, are not limited to the older adult population. Declines in performance on speech-in-noise tasks can begin as early as 40 years old. Yilmaz et al. (2007) found that speech-in-noise performance begins to decline significantly at the age of 40 and continues to worsen. Subjects in their 60s performed 37% worse on speech-in-noise tasks than subjects in their 40s. Thus, middle-aged adults can begin to experience difficulties with speech-in-noise tasks, and thus auditory perception.

Dichotic Listening

Dichotic listening occurs when the stimulus presented is not the same between the ears. Dichotic listening is achieved superficially by presenting different stimuli to a subject while listening through headphones. Dichotic listening is often used as a test for hemispheric lateralization of speech perception (Ingram, 2007). Dichotic listening allows audiologists to test the integrity of auditory pathway structures above the level of the cochlea (Meyers, et al. 2001). Meyers et al found that the Dichotic Words Listening Task, a test of dichotic listening, was useful in determining the presence of a brain injury affecting the auditory processing system as well as the degree of acute injury as measured by loss of consciousness. Dichotic listening is also included in the test battery for diagnosing Auditory Processing Disorder (APD).

Test performance is variable by ear in dichotic listening tasks. Listeners tend to score a higher percent correct on materials presented to the right ear over materials presented to the left ear. This phenomenon is called the right ear advantage (REA) (Kimura, 1967). The REA is shown in 95% of all right-handed subjects (Bryden, 1988). This phenomenon is more variable in left-handed listeners (Wilson & Leigh, 1996). Wilson and Leigh (1996) reported that subjects performed on averaged 9.9% better with their right ear than with their left. This phenomenon can be explained by the fact that the dominant cerebral hemisphere is most often the hemisphere opposite the dominate hand (Bryden,1988). Thus, right-handed individuals will have a dominate left cerebral hemisphere. Furthermore, Kimura (1967) posits that, because major ascending pathways in the central auditory nervous system are contralateral, right ear signals cross to the left side of the cerebrum at the brainstem level and ascend to the left auditory cortex. The transcollosal pathway connects the auditory cortex in the left hemisphere and associated cortex in the right hemisphere across the corpus callosum. The transcollosal pathway allows information from the left ear that travels to the cortex in the right hemisphere to reach the language processing center in the left hemisphere (Kimura, 1967). Because the language processing portions of the brain are on located in the left auditory cortex, the input from the right ear will arrive slightly earlier than the input from the left ear. The time different requires the brain to hold the signal from the right ear in memory in order to process and recall the input from the left ear. The activation of memory and attention are also considered as compounding factors that increase task difficulty, thus leading to the observed REA (Kinsbourne, 1970). The theory behind the REA strives to explain both the process that causes REA as well as the difficulty with dichotic listening tasks

It has been well documented that performance on performance on dichotic listening tasks are also correlated with age: older listeners perform consistently poorer than younger listeners performing the same dichotic task (Strouse & Wilson, 2001; Strouse et al., 2000; Jerger, Oliver, & Pirozzolo, 1990). Roup et al. (2006) showed that young adult listeners with no hearing loss successfully recalled an average of 86.9% of the words presented to their right ear and 84.4% of words presented to their left ear. Comparatively, older listeners only recalled 48.3% in the right ear and 36.1% in the left ear. Therefore, older adults perform significantly worse than young adults on dichotic listening tasks. Moreover, the REA is more pronounced in older adults than it is in young adults. Roup et al. (2006) reported young adult listeners had an REA of 2.5% while older adults had a 12.2% REA. Thus, the REA is significantly larger in older listeners than in young adult listeners.

Older adults also exhibit difficulties depending on the stimuli used, much like in speech-in-noise testing. Strouse-Carter and Wilson (2001) examined relative difficulty of words used as stimuli on a dichotic listening task. While older adults scored significantly lower overall than their young adult counterparts, older adults were more likely to correctly identify stimulus items identified as linguistically ‘easy’ than ‘hard’ items.

Perception of Speech Recognition Deficits

There have been numerous studies on the stereotypes and stigmas associated with hearing deficits. In order to better understand these studies as a cohesive group, David and Werner (2015) reviewed literature from January 1982 to December 2014 on stigma and hearing loss via a scoping review. A scoping review is an exploratory project that systematically maps the literature on a topic, while also identifying key concepts, theories and sources of evidence for that topic. The literature review consisted of twenty-one publications. The study then summarized current research findings and drew conclusions for future research and clinical care in this area. The results of this scoping review noted that the most common stereotypes associated with hearing difficulties are that: hearing difficulties occur only in older people, hearing aids are only for older people, and hearing aids make people look older. Other stereotypes included being less communicatively effective and being less sociable and friendly.

Stigmas surrounding hearing aids and hearing loss change with age. Erler and Garsteski (2002) found that younger women perceive greater stigma about hearing aids and hearing loss than older women. However, the stigma is associated most strongly with hearing loss than with hearing aid use. This suggests that hearing loss management is seen more positively than hearing loss without management.

Thus, the stigmas surrounding hearing loss can change the way a person deals with hearing loss and difficulty with speech understanding. David and Werner's review (2015) noted that hearing deficits cause a perceived threat to social identity and threatens the stability of social interaction. Furthermore the review showed that the respondents tended to seek help after going through a long phase of denial and concealing of the hearing loss. All of the studies reviewed reported that participants concealed hearing difficulties. Avoidance behaviors such as pretending to hear what was being said, refraining from making explicate demands that might help with communication and not wearing hearing aids were also noted in most subjects. Subjects also reported increases in social anxiety. The way in which a person perceives hearing loss and consequently how it is managed will, therefore, but influenced by the ideas surrounding hearing loss, what that means in relation to aging, and how others will perceive the loss.

Test Anxiety

Test anxiety is a type of performance anxiety that affects the way an individual feels while taking a test. Spielberger (1995) explains that there are two important principles of anxiety. The first principle is that as task difficulty increases, the likelihood that anxiety produces undesirable effects increases. Conversely, if task difficulty decreases, the likelihood that anxiety produces undesirable effects also decreases. The second principle is that anxiety is more likely to enhance performance when the performer is highly proficient at the task. Spielberger presented a monotonic relationship between test anxiety and task performance, demonstrating that anxiety can be both facilitating and debilitating. Thus, test anxiety does not always cause poor performance. As further explained by Pekrun (1992), there are various ways that emotions can affect learning and achievement in students. This relationship is complex: negative emotions have the ability to produce facilitating and debilitating effects on performance. Thus, predicting emotional influence on performance is difficult. Additionally, emotions have a feedback loop that influence future performance. Furthermore, Zeidner (1998) states that test anxiety is typically accompanied by a negative emotional experience and a decrease in performance. Zeidner then continues to explain that there is a complex relationship between test anxiety and performance, with facilitating anxiety increasing performance and debilitating anxiety decreasing performance.

Test anxiety, however, is influenced by other factors besides proficiency, task difficulty, and emotional reaction. Test anxiety, as explained by Hembree (1988), is inversely related to self-esteem and performance in most cases. Test anxiety is directly related to other forms of anxiety. Other causes of test anxiety, including ability, gender, and age, vary by individual. Hembree (1988) further categorizes test anxiety into two component factors: worry and emotionality. Worry is the apprehension a person feels when reflecting upon his or her performance. Emotionality is the physiological reactions that are stimulated by worry. These reactions include perspiration and increased heartrate, and a reduction in saliva.

Although no specific cause of test anxiety had been identified, test anxiety can be measured. There are many ways to go about assessing anxiety. Rose and Davine (2014) explain that there are three components that need to be measured when considering patient anxiety:

general distress, physiological hyperarousal, and anhedonia. Furthermore, tools for assessment should capture the content of study, have an appropriate balance between precision and respondent burden, and have a precision that has suitable range and distribution for the sample of the study.

Anxiety and Aging

The aging process can cause anxiety in individuals (Lasher & Faulkender, 1993). However, little research has been conducted analyzing anxiety rates and causes across the lifespan. Most research focuses on children and adolescent populations, as these populations are perceived to be the populations that are most likely to exhibit anxiety disorders.

In order to measure anxiety related to aging, Lasher and Faulkender (1993) created the Anxiety about Aging Scale (AAS). The AAS posits that anxiety surrounding aging is a multidimensional construct that consists of four main parts: Fear of Older People, Psychological Concerns, Physical Appearance, and Fear of Loss. Thus, the AAS assesses four factors that contribute to age-related anxiety: Fear of Old People, Psychological Concerns, Physical Appearance, and Fear of Loss. Lasher and Sargent-Cox, Rippon, and Burns (2013) examined the validity of the AAS. To examine the AAS validity, 3,000 questionnaires were presented as an investigation of health and health attitudes to residents from the Australian Capital Territory. The AAS was a subset of the questionnaire and was always the last set of questions within the questionnaire. Of the 3,000 questionnaires, 776 were completed. Responses on the questionnaire revealed the internal consistency, measured by Cronbach's α, of the four factors was good for Fear of Old People ($\alpha = 0.80$), Psychological Concerns ($\alpha = 0.80$), and Physical Appearance dimensions (α = 0.73), while it had only moderate internal consistency for the Fear of Loss (α = 0.69). Fear of Losses was the exception, due to the differing meanings across groups. Furthermore, the results indicate that AAS factor loadings are equivalent across males and females, and age groups for all factors save Fear of Loss. Thus, the AAS can provide can provide meaningful and comparative statements across age and gender regarding anxiety about aging within the context of Fear of Old People, Psychological Concerns, and Physical Appearance factors.

In studying age-related anxiety, Gross et al. (1997) found that, compared with younger participants, older participants reported fewer negative emotional experiences and greater emotional control. Findings regarding emotional expressivity were less consistent, but when there were age differences, participants reported lesser expressivity. A study by Fortner and Neimeyer (1999) found that lower ego integrity, more physical problems, and more psychological problems are predictive of higher levels of aging-related anxiety in elderly people, especially when considering death and dying. These studies show that older adults should have less anxiety than their young adult peers, and thus would be less susceptible to test anxiety.

In regards to the middle-aged population, few studies have focused on anxiety levels related to the aging process. O'Brien and Hummert (2006) examined memory performance in middle-aged adults ranging from 48 years old to 62 years old. The participants were primed in one of three conditions: being told that that their task performance would be compared to young adults, being told that their task performance would be compared to older adults, or they were not given any comparison information. Results from the O'Brien and Hummert study showed that participants who were told their results would be compared to older adults performed worse than participants in the other two conditions. When comparing these results to implicit age identity, only participants who had begun seeing themselves as older adults showed decreased task performance, indicating that self-stereotyping in relation to age have a negative effect on test performance. Furthermore, O'Brien and Hummert analyzed pretest anxiety and posttest anxiety. Individuals with the older adult comparison primer had significantly higher anxiety levels than those who did not get any comparison information. Participants in the older comparison condition also reported feeling significantly higher levels of anxiety that those of the other two conditions. This phenomenon can be explained by the self-stereotyping theory which states that invoking a comparison with older adults in a study of aging and memory will prime negative stereotypes about aging, older adults, and memory loss. To date, this theory is only thought to affect memory performance if the stereotype if self-relevant, thus explaining why the self-stereotyping phenomenon only occurs in middle-aged adults.

It would be of interest to learn how anxiety related to aging changes as an individual approaches the older adult stage of life. Anecdotal evidence claims that, as individuals' age they will become increasingly anxious about the aging process until the individual accepts that they are in the older adult stage of life.

Test Anxiety and Audiology

Patient comfort in audiology is important because it ensures that the patient cooperates with the testing. The more comfortable a test is, the more willing a patient is to participate in the test. However, little research has been done regarding test anxiety in clinical audiological settings. Because audiologists most commonly see elderly populations, it is of interest to study test anxiety in the elderly population. Social isolations and elevated depression rates are associated with anxiety in the elderly population, therefore clinical test anxiety needs to be analyzed and addressed in elderly populations. (Cornwell & Waite, 2009)

Roup and Chiasson (2010) analyzed levels of self-reported anxiety in response to dichotic listening tasks in young adult listeners. The tests were ranked in order of difficulty: dichotic digits, dichotic words, and dichotic CVs. Despite the differences in difficulty of the dichotic tasks, there was no significant difference in state anxiety between the three tasks. Furthermore, for a subset of participants that were tested a second time, there was no significant change in state anxiety between session one and session two. However, an overall increase in anxiety in response to a dichotic task was observed. These results imply that, while changing the stimulus did not affect anxiety, the task of listening dichotically induces anxiety in young adult listeners.

Beynon, Clarke, and Baguley (1995) examined the patient comfort during a comprehensive range of audiological tests used in diagnosing vestibular disorders. Subjects suspected of having Meniere’s disease were retrospectively presented with a questionnaire after completing the full range of clinical testing. This study showed that some tests, such a caloric testing, were inherently more uncomfortable than others. There was not, however, a correlation between the patients tolerance rating and their average comfort. Additionally, there was not a correlation between the age of the patient and their average comfort.

Makersie and Cones (2011) measured both subjective and psychophysical responses of anxiety in listeners in effortful situations. Individuals were presented with listening tasks form the Dichotic Digits Test with three levels of difficulty. The individuals’ heart rate, skin conductance, skin temperature, and electromyography activity, as well as a subjective rating of task load, were recorded throughout each task. Results indicate no significant change in performance across task difficulty. However, skin conductance and EMG activity were directly related to task difficulty. There was no relationship between subjective and psychophysiological measures of anxiety. Thus, as task difficulty increases, the psychophysiological responses associated with stress also increase.

Another study by Kelly-Campbell and Parry (2014) used the Cognitive Anxiety Scale (CAS) to determine the relationship between state anxiety and audiometric variables during an initial audiological consultation in adults with hearing impairment. Thirty-five adults with hearing impairment participated during their first consultation with an audiologist. Each subject was interviewed prior to audiological assessment to obtain information about cognitive anxiety. Results showed that state anxiety was significantly related to understanding speech in noise. Additionally, results demonstrated that state anxiety level and the level of understanding speech in noise were both contributing factors on the decision to adapt hearing aids. Kelly-Campbell and Parry posit that in the future, speech-in-noise testing should be used more consistently during the audiological appointment to both draw the patient's attention to their lack of speech in noise understanding and make testing more closely resemble the real world. Furthermore, it may be possible to use the CAS to analyze a patient's readiness for rehabilitation and gauge the benefit a patient will receive from intervention.

These studies all demonstrate that audiologic testing changes levels of anxiety in patients. Additionally, as the perceived difficulty of the audiologic test increases, so does the anxiety of the patients. This mirrors the results that studies examining school related test anxiety. Therefore, test anxiety is inherent in audiologic testing and could influence the results of the audiologic tests.

Purpose of the Present Study

The primary purpose of the present study was to examine if anxiety levels change as a result of speech recognition testing. To do this, self-reported state anxiety levels as a function of speech recognition test performance were measured in three groups: young adults with normal hearing, middle-aged adults with minimal hearing loss, and older adults with varying degrees of sensory-neural hearing loss. It was predicted that subjects would report increased states of anxiety as a function of the increasing degradation of the speech stimulus in speech recognition tests. It was predicated that middle-aged adults with minimal hearing loss would exhibit a greater level of anxiety than young adults because young adults would not have difficulty with speech recognition testing while middle-aged adults would have difficult with speech recognition testing. Furthermore, middle-aged adults with hearing loss would exhibit greater levels of anxiety than older adults due to the fact that older adults expect listening difficulties whereas middle-aged adults do not.

In order to test these hypotheses, the changes in self-reported state anxiety due to speech recognition testing were compared between young adults with normal hearing, middle-aged adults with minimal hearing loss, and older adults with varying degrees of hearing loss. This was done to see if a relationship existed between age and change in anxiety level due to speech recognition testing. The changes in anxiety levels were compared to performance on speech recognition tests within each age group to see if a relationship between anxiety level and test performance is present. Speech recognition test results were also compared within each age group to see if age had an effect on speech recognition performance.

Chapter 2

Methods

Subjects

Sixty-six adults were recruited from The Ohio State University, The Ohio State Speech-Language-Hearing clinic, and the surrounding area of Franklin County for this project. The adults were separated into three age groups: 1) 30 young adults 18-39 years of age; 2) 19 middl-aged adults 40-59 years of age; and 3) 17 older adults 60-89 years of age. There were more females tested than males: (83.3%) of young adult subjects were female, (78.9%) of middle-aged subjects were female, and (41.2%) of older adults were female. Subjects were required to have symmetric hearing (no greater than a 10 dB interaural difference in air conduction thresholds at 500-4000 Hz). For the young adult group, normal hearing was defined as thresholds ≤ 20 dB HL at 250-8000 Hz. For the middle-aged and older adult groups, hearing loss could not exceed a mild SNHL hearing loss at 500 Hz (40 dB HL) and a moderately-severe SNHL at 4000 Hz (70 dB HL). Subjects were all right handed, in order to control for the variability in dichotic speech recognition performance associated with left-handedness (Wilson & Leigh, 1996). Subjects had no history of otic disease within the last year, no history of ototoxic medications, normal otoscopic findings, normal tympanometry measures, and were native English speakers (Roup et al., 1998, Wiley et al., 1996). Subjects 60 years of age and older were screened with the Mini Mental State Examination (scores > 25; Folstein et al.) to ensure normal cognitive function. All audiometric and experimental testing occurred in a sound-attenuating booth (IAC, Model 403ATR). Each subject was compensated for participating in this study. The present study was approved by the Behavioral and Social Sciences Institutional Review Board.

Materials

There were four different audiologic clinical tests used in the study: 1) QSIN test (Killion et al., 2004); 2) the Revised Speech Perception in Noise (R-SPIN) test (Bilger et al., 1984); 3) the Words in Noise (WIN) test (Wilson, Abrams & Pillion, 2003); and the Dichotic Digits Test (Strouse & Wilson, 1999). The QSIN test assesses sentence recognition in multitalker babble. Subjects repeat the entire sentence. Five words in each sentence are denoted as key words and are scored as correct or incorrect. There are six sentences per list, totaling thirty key words. The first sentence is presented at +25 dB SNR, with each subsequent sentence decrease by 5 dB SNR. The results of the QSIN are used to determine the subject's speech recognition threshold, or the SNR at which the subject recognized 50% of the key words correctly. The R-SPIN test, like the QSIN test, assesses sentence recognition against multitalker babble. Subjects are instructed to repeat the last word in each sentence. Each sentence list contains 50 sentences; half are high predictability while the other half are low predictability. High predictability sentences contain contextual clues that allow the subject to be able to predict the last word in the sentence. Low predictability sentences do not contain any context clues so that the last word cannot be predicted. The sentences are presented at +8 dB SNR. The results are calculated by percent correct, and can be separated into high predictability and low predictability for further analysis. The WIN assesses word recognition against multitalker babble. This test contains 35 sentences divided into 7 groups of 5 sentences each. The first group is presented at +24 dB SNR, with each subsequent group presented at 4 dB SRN lower than the last. Every sentence begins with 'say the word' followed by the target word of the sentence. Subjects must repeat the target word. Scores are total percent correct, which is then converted into a 50% threshold. The Dichotic Digits Test measures dichotic speech recognition. This test presents the subject with dichotic pairs of up to 3 digits. There are 54 sets of pairs. Digits are the numbers 1- 10, excluding the number 7. Subjects must repeat all of the digits without a particular order. Results are calculated by percent correct for 1-, 2-, and 3- set pairs.

The S-Anxiety subscale of the State-Trait anxiety inventory (STAI, Form Y-1; Spielberger, 1983) was used to measure the subjects' self-reported states of anxiety. The S-anxiety subscale asked subjects to rate to what degree they agreed with each statement about their current state of feelings. The subscale consisted of 20 statements. These statements were a mix of positive statements, such as 'I feel calm,' and negative items, like 'I feel anxious.' Subjects rated each statement using a 4-point scale, with 1 = not at all and 4 = very much so. Scores could range from a total of 20, the lowest level of state anxiety, to 80, the highest level of state anxiety.

Procedures

After ensuring that subjects met inclusion criteria, subjects completed a STAI to determine a baseline anxiety level. Subjects then completed all four speech recognition tests within a single session. Before each speech recognition test, the task was explained to the subjects to ensure understanding of the task. After each speech recognition test, the subject was given the S-Anxiety subscale of the State-Trait anxiety inventory test to measure the subjects' self-reported states of anxiety as it is related to the speech recognition test. The order in which the tests were presented was counterbalanced across subjects. Each test was presented from a CD player (Sony CE375) through a 2-channel audiometer (Grason Stadler, Model 61) at 50 dB HL for young adults and 30 dB SL (re: 2000 Hz threshold) for middle-aged and older adults via insert earphones. The data was coded without identities and stored on a password-protected computer in the locked research laboratory.

Chapter 3

Results

Speech Recognition Performance

Figure 1 presents the mean speech recognition performance in young adults, middle-aged adults, and older adults. Panel 1 shows the mean performance between the right and the left ear in young adults, middle-aged adults, and older adults on the R-SPIN test. Panel 2 shows the mean performance between the right and the left ear in young adults, middle-aged adults, and older adults on the QSIN test. Panel 3 shows the mean performance between the right and the left ear in young adults, middle-aged adults, and older adults for the WIN test. And Panel 4 shows the Ear Advantage for 1-pair, 2-pair, and 3-pair dichotic digits for young adults, middle-aged adults, and older adults. Ear Advantage was calculated by subtracting the left ear score from the right ear score. As expected, for each age group ear advantage increased as the number within the pair increased.

Overall, older adults performed poorer in comparison to the other two groups. As is shown in Figure 1, young and middle-aged adult performance is comparable for the R-SPIN, QSIN, and WIN tests. Older adults perform significantly worse than the younger and middle-aged adults for all four measures of speech recognition. On the R-SPIN, older adults scored 68% correct, while the young adults and middle-aged adults scored 90% correct. On the QSIN, older adults were found to have an 8.2 mean dB SNR, while young adults had a 1.0 dB SNR and older adults had 1.8 dB SNR. On the WIN, older adults were found to have a mean dB SNR of 13.5, whereas the young adults had a mean dB SNR of 5.9 and the middle-aged adults had a mean dB

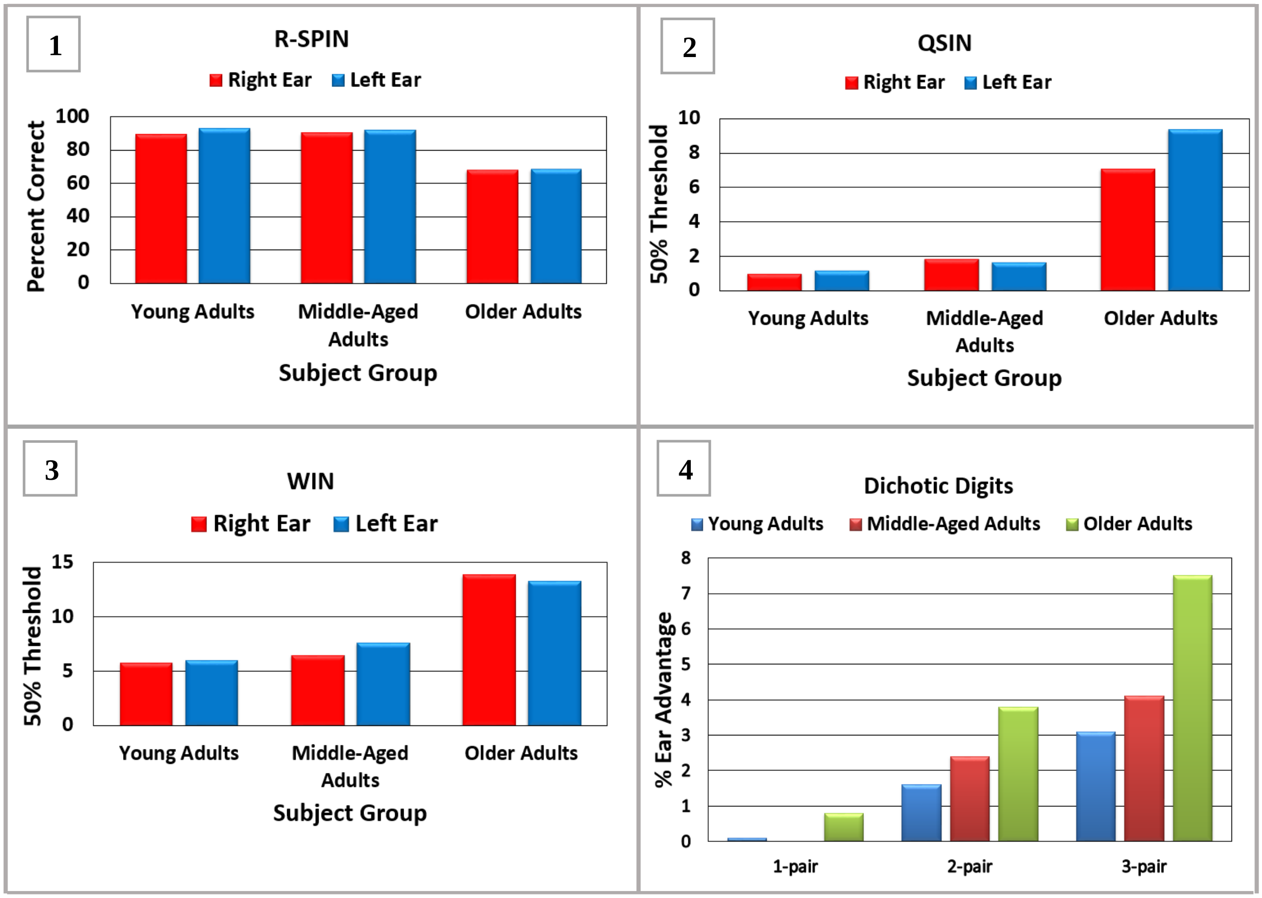

Figure 1: Speech recognition performance for each speech recognition test. Panel 1 shows Right Ear (red) and Left Ear (blue) performance on the R-SPIN. Panel 2 shows Right Ear (red) and Left Ear (blue) performance on the QSIN Test. Panel 3 shows Right Ear (red) and Left Ear (blue) performance on the WIN test. Panel 4 shows Ear Advantage (Right Ear – Left Ear) for 1-pair, 2-pair, and 3-pair dichotic digits. In each panel, results are presented for young, middle-aged, and older adults.

SNR of 7.0. On the Dichotic Digits task, older adults correctly recalled 77.8% of digits from the right ear and 63.9% from the left ear on the 3-pair digits. Contrastingly, young adults recalled 89.3% from the right ear and 83.6% from the left ear, while the middle-aged recalled 84.0% from the right ear and 75.9% from the left ear. These results also show that middle-aged adults performed better than older adults, but not as good as young adults.

State Anxiety and Speech Recognition

Figure 2 presents mean STAI scores for the baseline and after each of the four speech recognition measures. Figure 2 shows that state anxiety increased from baseline to each of the four tests in all three test groups. A two-way analysis of variance (ANOVA) with group as the between subjects variable and test type as the within subjects variable revealed no significant difference for group ($F_{2, 63} = 2.2$; $p < .05$). Therefore, there were no differences in self-reported state anxiety (STAI scores) between the young adult, middle-aged adult, or older adult groups.

In contrast, results revealed a significant main effect for test type ($F_{4,252} = 17.2$; $p < 0.05$). Post hoc paired samples t-tests with Bonferroni correction were used to assess the main effect of test type for each group. In the young adult group, there was a significant difference between the baseline and post-dichotic digits STAI scores ($t_{18} = 0.011$; $p < 0.0125$). This difference means that state anxiety levels significantly increased after the dichotic digits test for young adults. In the middle-aged adult group, a significant difference between the baseline STAI scores and STAI scores post-each of the four speech recognition tests: post-RSPIN STAI scores ($t_{18} = -2.9$; $p < 0.0125$), post-QSIN STAI scores ($t_{18} = -3.4$; $p < 0.0125$), post-WIN STAI scores ($t_{18} = -4.2$; $p < 0.0125$), post-dichotic digits STAI scores ($t_{18} = -6.7$; $p < 0.0125$). Thus, in middle-aged adults, state anxiety levels significantly increased as a result of each of the four tests of speech

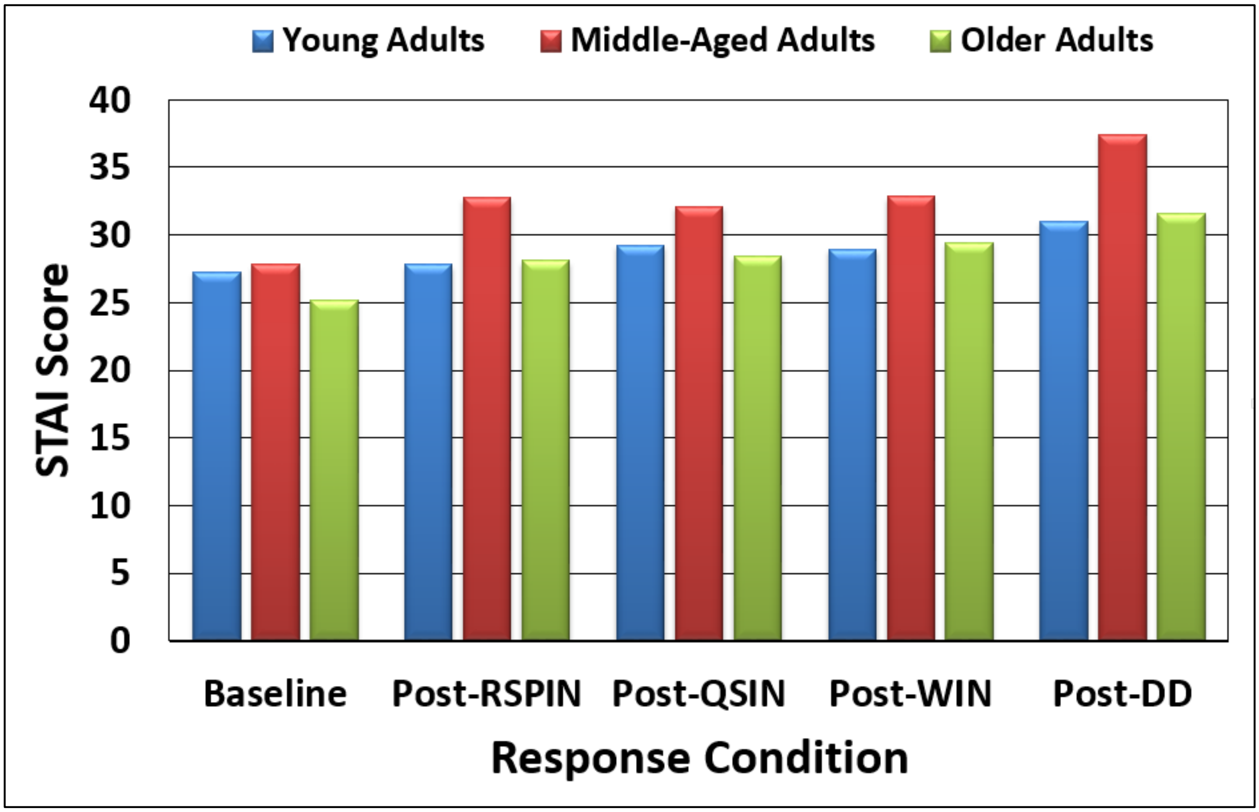

Figure 2: Mean STAI scores for young adults (blue), middle-aged adults (red), and older adults (green) across conditions (baseline, post-RSPIN, post-QSIN, post-WIN, and post-Dichotic Digits)

recognition used in this study. In the older adult group, significant differences between baseline and the post-QSIN STAI scores ($t_{17} = 0.009$; $p < 0.0125$), and between the baseline and the post-dichotic digits STAI scores ($t_{17} = 0.004$; $p < 0.0125$) were found. Therefore, state anxiety levels significantly increased in the older adult group after the QSIN and dichotic digits tests.

Figure 3 presents individual STAI scores as a bivariate plot with baseline STAI scores on the abscissa and the post-test STAI scores on the ordinate for each of the four speech recognition tests. Points below the diagonal line indicate greater state anxiety before speech recognition testing. Points above the diagonal line indicate greater state anxiety after speech recognition testing. Points on the diagonal line indicate no change in state anxiety. Figure 3 displays the variability both with testing condition and within age groups. In general, the dichotic digits results seem to show the greatest overall increase in anxiety across all age groups because a larger portion of the data points lie above the diagonal line. However, there does not seem to be any interaction of age and change in anxiety levels. Furthermore, the general increase of anxiety post-test does not show any specific patterns. The lack of pattern is consistent across test conditions.

Table 1 reports the subjects' response percentages to the question "Does anxiety cause you to avoid social situations with background noise, or difficult listening situations?" Table 1 shows that middle-aged adults are more likely than young adults and older adults to report that they avoid social situations with background noise or difficult listening situations (26% yes in middle-aged adults versus 13% in older adults and 3% in young adults). More yes responses to this questions suggest that middle-aged adults are more likely than any other age group to avoid difficult listening situations because of their anxiety levels.

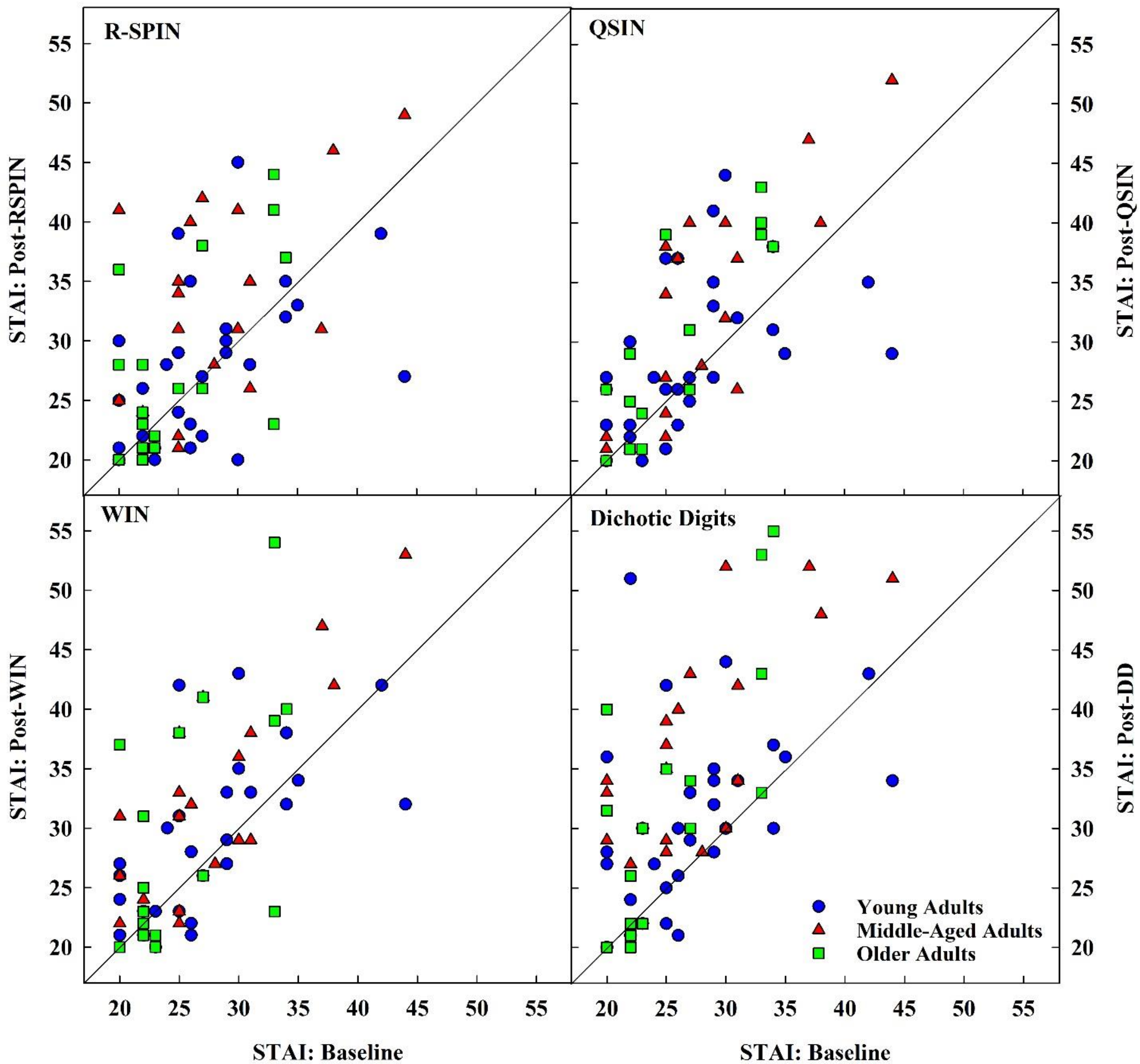

Figure 3: Individual data presented as bivariate plots of baseline STAI score (abscissa) and post-speech recognition STAI score (ordinate): post-RSPIN, post-QSIN post-WIN, and post-DD.

Table 1: Response rates to the question "Does anxiety cause you to avoid social situations with background noise, or difficult listening situations. Comments made by induvial participants were categorized and presented in the comments section.

	Yes (%)	No (%)	Comments
Young Adults	**3%**	**97%**	**1) Noise is annoying when anxious**
Middle-aged Adults	**26%**	**74%**	**1) Difficulty with background noise** **2) More anxious with more important speakers** **3) No additional comments**
Older Adults	**13%**	**87%**	**1) Avoids restaurants/crowds** **2) Difficulty with > 5 people**

Performance and Anxiety

Figure 4 shows STAI differences scores plotted as boxplots for each testing condition in young adults, middle-aged adults, and older adults. STAI difference scores were calculated by subtracting the baseline STAI scores from the STAI scores post-each speech recognition test. The boxplots show the range of the data as well at the means of each age group across test conditions. Each boxplot shows the median (black line), the mean (grey line), the 25^{th} and 75^{th} percentiles (lower and upper edge of the box), 10^{th} and 90^{th} percentiles (the whiskers) and the outliers (the dots). Figure 4 shows the middle-aged adults had the highest STAI difference scores across all testing conditions. Young adults, however, had the most variable STAI difference scores: STAI difference scores for the R-SPIN, QSIN, and Dichotic Digits in the young adult age group had largest range of scores, as well as the most outlying points. Older adults had the largest range of STAI difference scores for the WIN, but young adults had the largest amount of outliers. STAI difference scores for the Dichotic Digits test had the highest mean compared to the other testing conditions in all three age groups. There was not one testing condition across age groups that had the lowest mean STAI difference score.

In order to determine if increases in state anxiety impacted performance on speech recognition tests at an individual level, each of the outliers shown in Figure 4 (the dots) were examined in greater detail. The individual data for these outlying points are presented in Table 2. Outliers that showed abnormally high ($\geq 90^{th}$ percentile increase) increases in STAI scores were analyzed to see if the smallest changes in STAI indicate near perfect performance while the largest changes in STAI indicate poor performance. Analysis of the outlier subjects revealed seven young adult subjects, three middle-aged subjects, and three older adult subjects had abnormally high ($\geq$ 90th percentile) STAI difference scores in at least one testing condition. The abnormally high STAI difference scores were accompanied by significantly poorer (< 1 standard deviation of the mean) on one of the speech recognition tests in four young adult subjects, two middle-aged subject, and two older adult subjects. Additionally, five of the young adult subjects, one middle-aged subject, and one older adult subject performed significantly better (> 1 standard deviation of the mean) on one of the speech recognition tests. Only two young adult subjects and one older adult subject showed abnormally high STAI difference scores and significantly poorer performance on the same speech recognition test. It should also be noted that the speech recognition test with the largest number of abnormally high STAI difference scores was the Dichotic Digits test.

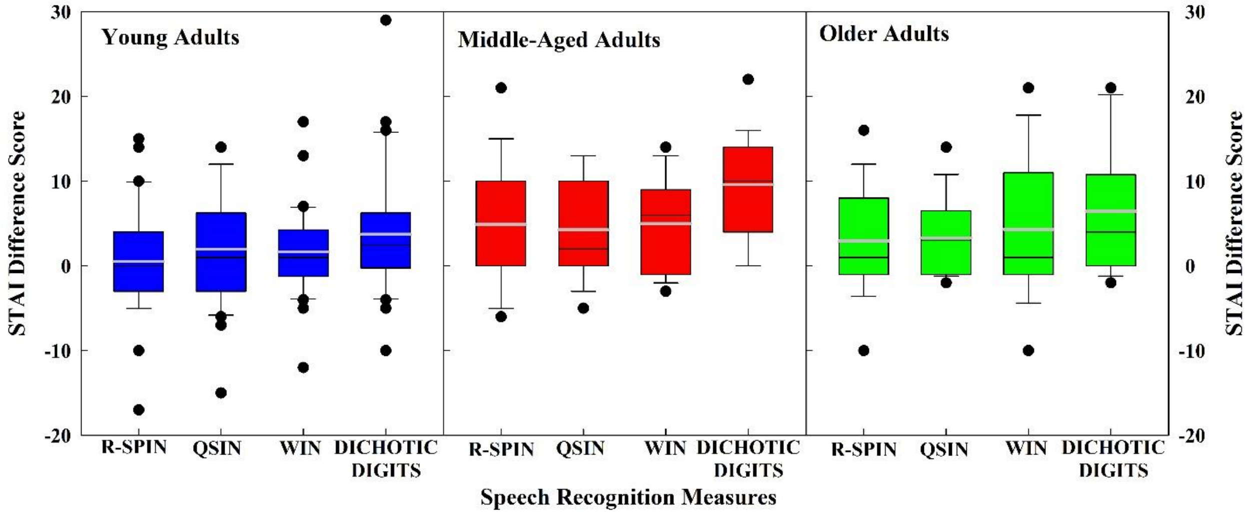

Figure 4: Mean difference STAI scores presented as box plots for the young adult group (blue), middle-aged adult group (red), and the older adult group (green) across test conditions (RSPIN, QSIN, WIN, and Dichotic Digits). Each box plot includes the: mean (grey), median (black line), 25th percentile (lower edge of box), 75th percentile (upper edge of box), 10th percentile (lower whisker), 90th percentile (upper whisker), and outliers (dots). Difference STAI scores were calculated by subtracting the baseline STAI score from the post-test STAI score in each condition.

Table 2: Individual data from the subjects with abnormally high increases in STAI scores. STAI scores in red fall above the 90th percentile. Recognition performance in blue indicates one standard deviation below the group mean. Recognition performance in green indicates one standard deviation above the group mean.

	R-SPIN % Correct	QSIN dB SNR	WIN dB SNR	Dichotic Digits 3-Pair EA
YA Subject # 21				
Performance	94.0 %	2	7.2	-4
STAI Increase	**15**	**14**	**13**	0
YA Subject # 26				
Performance	96%	-3	4.8	-4
STAI Increase	**14**	12	**17**	**17**
YA Subject # 4				
Performance	90%	3	6.8	-2
STAI Increase	**10**	7	6	8
YA Subject # 19				
Performance	84%	-1	5.2	11
STAI Increase	5	6	**7**	7
YA Subject # 28				
Performance	90%	7	5.6	1
STAI Increase	-10	**14**	5	14
YA Subject # 30				
Performance	92%	1	-0.8	8
STAI Increase	4	8	-1	**29**
YA Subject # 10				
Performance	96%	-2	4.4	-2
STAI Increase	0	0	4	**16**
MA Subject # 12				
Performance	92%	9	7.2	15
STAI Increase	**21**	1	11	13
MA Subject # 3				
Performance	96%	0	7.2	-11
STAI Increase	11	10	6	**22**
MA Subject # 15				
Performance	86%	3	2.8	12
STAI Increase	15	13	14	16
OA Subject # 10				
Performance	62%	17	14.8	3
STAI Increase	**16**	6	17	**20**
OA Subject # 13				
Performance	64%	18	16.4	1
STAI Increase	1	**14**	13	10
OA Subject # 1				
Performance	80%	6	10.8	-4
STAI Increase	8	10	**21**	**20**

Chapter 4

Discussion

The purpose of this study was to determine if anxiety levels changed as a result of speech recognition testing across three different age groups: young adults, middle-aged adults, and older adults. Additionally, this study looked at if changes in anxiety levels were related to test performance across each of the four test conditions.

Between group comparisons of recognition performance revealed that older adults overall performed more poorly than young adults in all measures of speech recognition. The performance difference between young adults and older adults is consistent with previous findings (Gordon-Salant, 1986; Tun et al., 2002; Souza & Turner, 1994; Dubno et al., 1984). Middle-aged adult's performance was comparable to young adult performance on both the RSPIN, QSIN, and WIN tests. Middle-aged adults performed in-between young adult and older adult performance on the Dichotic Digits test. Decreases in performance by middle-aged adults is consistent with the results from Yilmaz et al. (2007), which show that performance on speech-in-noise tasks begin to decline significantly at the age of 40 years and continues to worsen. However, results from Yilmaz et al. do not explain why middle-aged adults perform poorer on some speech recognition tests and similar to young adults on others in the present study. The variability in performance compared to young adults across testing conditions could indicate that some measures of speech recognition are more sensitive to the age of onset for listening difficulties in noise. The sensitivity could be related to the amount of cognitive load the speech recognition test puts on the subject's auditory processing system.

STAI score analysis revealed that there was no significant differences between age groups. The lack of difference is state anxiety levels between age groups indicates that age is not a factor that influences changes in state anxiety levels due to speech recognition testing. However, within group changes in state anxiety levels were noted in each of the age groups. All three age groups showed a significant increase in anxiety in the post-Dichotic Digits condition. Increases in anxiety levels post-dichotic testing were also shown by Roup and Chiasson (2011). Because task difficulty is known to influence anxiety levels (Zeidner, 1998), increases in anxiety post-dichotic digits can be attributed to the difficult of the task. In older adults, a significant increase in anxiety was also noted post-QSIN. Task performance is also known to effect anxiety levels (Ball 1995). Because older adults perform poorer than both other age groups on the QSIN, increase anxiety levels could be attributed to decreased performance as well as task difficulty. Middle-aged adults showed significant increases in anxiety in each of the four different testing conditions. This increase in anxiety levels was predicted by the question "Does anxiety cause you to avoid social situations with background noise or difficult listening situations?" that was asked of all participants at the beginning of the study. This increase in state anxiety levels can only be attributed to decreased test performance in the dichotic digits test and the WIN test. In the RSPIN and QSIN, increased anxiety levels could not have been caused by decreased performance because middle-aged adults performed comparably to young adults. O'Brien and Hummert (2006) showed that anxiety levels in middle-aged adults increased when participants thought test results would be compared to test results from older adults. Because each participant was told that the purpose of the study was to look at if anxiety levels changed as a result of speech recognition testing in three different age groups, middle-aged participants could have been unintentionally primed to think that their test results would be compared to those of older adult age group. An increase in state anxiety levels due to the belief that results would be compared to older adult results can be explained by self-stereotyping theory. Self-stereotyping theory states that invoking a comparison with a self-relevant stereotype group can prime negative stereotypes about that group, thus increasing state anxiety levels (O'Brien and Hummert, 2006). In this case, middle-aged adults who think that they could be considered in the same group as older adults will show increases in anxiety levels because they are primed negative stereotypes about aging, older adults, and memory loss.

The present study hypothesized that increases in state anxiety levels would correlate with a reduction in speech recognition test performance. However, the results did not support this hypothesis. Group analysis did not reveal a correlation between state anxiety levels and performance. After analyzing the outlying data points, there were only two instances of significantly poorer performance being accompanied by significant increases of anxiety. Thus, an abnormal increase in anxiety levels was most often accompanied by average or above average performance. The different test performance results for individuals who had significant increases in anxiety as a result of speech recognition testing can be accounted for by continuum of state anxiety levels on test performance. While heightened levels of anxiety can decrease test performance, the inverse is also true (Hembree, 1988). Heightened state anxiety levels can also increase test performance, which appears to be the case for these outlying subjects. Additionally, while lack of anxiety can help test performance, it can also hinder it. This is because the individual is not anxious enough to perform well on a test. Thus, anxiety and test performance have a bell curve relationship: too little or too much anxiety can result in decreased test performance (Hembree, 1988). Thus, it should be noted that increases in anxiety are not always a hindrance on performance and decreases in anxiety do not always cause increased test performance.

Limitations

Although the present study did find significant findings within age groups, it found minimal significant effects elsewhere. The lack of significant findings could be reflective of drawbacks to the current study. The present study presented messages in a controlled setting. The subjects were aware that their performance on the speech in noise test would not influence their everyday lives. Furthermore, the speech recognition tests did not adequately represent the situations in which middle-aged and older adults report hearing difficulty, despite the aim of speech recognition tests to imitate real-world difficult listening settings. In addition, the type and quantity of participants could have an influence on the results of the study. In general, more women participated then men. Furthermore, the research participants volunteered and came to the laboratory for the study. This could indicate that the research participants believe that participating in research is worth the time and efforts to participate. They type of individual that volunteers for a study looking at anxiety levels could be less effected by anxiety than the general population.

Clinical Implications and Further Research

The speech recognition tests used in the present study are often used evaluate a patient's speech-in-noise abilities. The results of these tests are often used to determine treatment options for the patient. Therefore, it is necessary to determine if performance on these tests if impacted by anxiety. Awareness of patient anxiety can be very beneficial in ensuring that speech recognition test results reflect the patient's true abilities to hear in noise. To reduce variability in the anxiety level and test performance relationship reported in the present study, a larger sample size should be tested to see if a relationship between anxiety and speech recognition test performance can be identified.

The present study found little difference between middle-aged and young adult test performance, However, Yilmaz et al. (2007) found that speech-in-noise performance began to significantly decline at age 40. This could be due to differences in cognitive demanding between the different tests of speech recognition. More cognitively demanding tests could put enough load on the middle-aged auditory processing system to show differences between young adults, middle-aged adults, and older adults. Thus, more research should be done on which speech recognition tests show decreased performance beginning at age 40.

Additionally, Makersie and Cones (2011), indicated that there was not a correlation between subjective and physiologic measures of anxiety in different dichotic tasks. Future research should see if this relationship between subjective and physiologic measures of anxiety holds true for other measures of speech recognition. Additional research could also consider the influence of the listener's gender, socioeconomic status, and first language on anxiety caused by speech recognition testing. Other factors to consider are the influence of the gender of the speaker in each speech recognition test on self-reported anxiety levels, and the influence of self-reported levels of anxiety pre-hearing impairment treatment affect the patient's reception of the hearing impairment treatment.

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Appendix 1: The State-Trait Anxiety Inventory

<u>Directions</u>:

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate box to the right of the statement to indicate how you feel *right* now, that is, *at this moment*. There are no right or wrong answers. Do not spend too much time on any one statement, but give the answer which seems to describe your present feelings best.

1 = not at all 2 = somewhat 3 = moderately so 4 = very much so

1	**I feel calm**	**1**	**2**	**3**	**4**
2	**I feel secure**	**1**	**2**	**3**	**4**
3	I am tense	1	2	3	4
4	I feel strained	1	2	3	4
5	**I feel at ease**	**1**	**2**	**3**	**4**
6	I feel upset	1	2	3	4
7	I am presently worrying over possible misfortunes	1	2	3	4
8	**I feel satisfied**	**1**	**2**	**3**	**4**
9	I feel frightened	1	2	3	4
10	**I feel comfortable**	**1**	**2**	**3**	**4**
11	**I feel self-confident**	**1**	**2**	**3**	**4**
12	I feel nervous	1	2	3	4
13	I am jittery	1	2	3	4
14	I feel indecisive	1	2	3	4
15	**I am relaxed**	**1**	**2**	**3**	**4**
16	**I feel content**	**1**	**2**	**3**	**4**
17	I am worried	1	2	3	4
18	I feel confused	1	2	3	4
19	**I feel steady**	**1**	**2**	**3**	**4**
20	**I feel pleasant**	**1**	**2**	**3**	**4**

Appendix 2: The Edinburgh Handedness Inventory

Edinburgh Handedness Inventory

Please indicate your preferences in the use of hands in the following activities *by putting a check in the appropriate column*. Where the preference is so strong that you would never try to use the other hand, unless absolutely forced to, *put 2 checks*. If in any case you are really indifferent, *put a check in both columns*.

Some of the activities listed below require the use of both hands. In these cases, the part of the task, or object, for which hand preference is wanted is indicated in parentheses.

Please try and answer all of the questions, and only leave a blank if you have no experience at all with the object or task.

	Left	Right
1. Writing	☐ ☐	☐ ☐
2. Drawing	☐ ☐	☐ ☐
3. Throwing	☐ ☐	☐ ☐
4. Scissors	☐ ☐	☐ ☐
5. Toothbrush	☐ ☐	☐ ☐
6. Knife (without fork)	☐ ☐	☐ ☐
7. Spoon	☐ ☐	☐ ☐
8. Broom (upper hand)	☐ ☐	☐ ☐
9. Striking Match (match)	☐ ☐	☐ ☐
10. Opening box (lid)	☐ ☐	☐ ☐
TOTAL(count checks in both columns)		

Difference	Cumulative TOTAL	Result
	/ *100 =	

Scoring:

Add up the number of checks in the "Left" and "Right" columns and enter in the "TOTAL" row for each column. Add the left total and the right total and enter in the "Cumulative TOTAL" cell. Subtract the left total from the right total and enter in the "Difference" cell. Divide the "Difference" cell by the "Cumulative TOTAL" cell (round to 2 digits if necessary) and multiply by 100; enter the result in the "Result" cell.

Interpretation (based on Result):

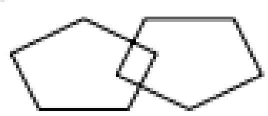
- below -40 = left-handed
- between -40 and +40 = ambidextrous
- above +40 = right-handed

Appendix 3: The Mini-Mental State Examination (MMSE)

Mini-Mental State Examination (MMSE)

Patient's Name: ______________________________ Date: ____________

***Instructions:** Ask the questions in the order listed. Score one point for each correct response within each question or activity.*

Maximum Score	Patient's Score	Questions
5		"What is the year? Season? Date? Day of the week? Month?"
5		"Where are we now: State? County? Town/city? Hospital? Floor?"
3		The examiner names three unrelated objects clearly and slowly, then asks the patient to name all three of them. The patient's response is used for scoring. The examiner repeats them until patient learns all of them, if possible. Number of trials: __________
5		"I would like you to count backward from 100 by sevens." (93, 86, 79, 72, 65, …) Stop after five answers. Alternative: "Spell WORLD backwards." (D-L-R-O-W)
3		"Earlier I told you the names of three things. Can you tell me what those were?"
2		Show the patient two simple objects, such as a wristwatch and a pencil, and ask the patient to name them.
1		"Repeat the phrase: 'No ifs, ands, or buts.'"
3		"Take the paper in your right hand, fold it in half, and put it on the floor." (The examiner gives the patient a piece of blank paper.)
1		"Please read this and do what it says." (Written instruction is "Close your eyes.")
1		"Make up and write a sentence about anything." (This sentence must contain a noun and a verb.)
1		"Please copy this picture." (The examiner gives the patient a blank piece of paper and asks him/her to draw the symbol below. All 10 angles must be present and two must intersect.) 
30		TOTAL

(Adapted from Rovner & Folstein, 1987)